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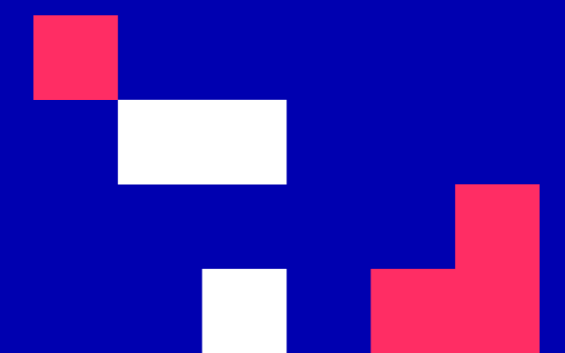


University of Cyprus

MAI650 Internet of Things

Vasos Vassiliou

September - December 2023





CS6xx Internet of Things (8 ECTS)

Course purpose and objectives: The purpose of the course is to provide an overview on IoT tools and applications and to introduce to students hands-on IoT communication concepts through lab exercises.

Learning outcomes: Upon completion of this course, students will be able to explain the definition and usage of the term “Internet of Things” in different contexts. More specifically, the students will know how to apply the knowledge and skills acquired during the course to build and test a complete, working IoT system involving prototyping, programming and data analysis

Teaching methodology: interactive face-to-face lectures, group activities and discussions, in class/lab activities, student presentations and guest lectures or significant recorded public lectures

Assessment: Final exam (50%), midterm exam (20%) and assignments/project (30%).

Main text:

Rajkumar Buyya, Amir Vahid Dastjerdi, Internet of Things Principles and Paradigms, Morgan Kaufmann; 1st edition, 2016

J. Biron and J. Follett, "Foundational Elements of an IoT Solution", O'Reilly Media, 2016.

Other reading:

Jamil Y. Khan and Mehmet R. Yuce, Internet of Things (IoT) Systems and Applications, 2019, ISBN 9789814800297

David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, and Jerome Henry, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, 2016, Cisco Press.



INTRODUCTION

IoT Devices

CONTENTS

1. Introduction
2. IoT Device Lifecycle
3. Architecture and Management
4. Communication Architecture
5. Examples

INTENDED LEARNING OUTCOMES

Upon completion of this introductory unit, students will be:

1. familiar with the IoT Devices.
2. familiar with the lifecycle of an IoT Device
3. familiar with the architecture and management of an IoT Device
4. familiar with the communication architecture of an IoT Device
5. presented with examples of IoT Devices

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Introduction

The "Things" characteristics

- Ability to collect data and interact with the environment
- Often constrained devices with limited processing capabilities
- Have the ability to transmit data
- Consisted of hardware and software
- Have a specific purpose generally meant to do one single task

What are IoT Devices?

- IoT devices are smart devices that can connect to the Internet.
- An IoT device is a hardware piece with a sensor that transmits data from one place to another over the Internet.
- IoT devices are basically smart devices which have support for internet connectivity and are able to interact with the other devices over the internet and grant remote access to a user for managing the device as per their need.

What technologies are used in IoT devices?

- The technologies used in these devices are:
 - low energy wireless and Bluetooth,
 - NFC,
 - LTE,
 - ZigBee,
 - wireless protocols
 - etc....

From normal to smart Devices

- To transform a normal device into an IoT/smart device, the following two functionalities need to be combined:
 - the device needs to be able to connect with the Internet in any way.
 - the device needs to be integrated with technology, such as sensors, functional software, technology with network connection support and actuators.

Different types of IoT Devices

- Wireless sensors
- Software
- Actuators
- Computer Devices

Different types of IoT Devices

Wireless sensors

Wireless sensors are standard measurement tools equipped with transmitters to convert signals from process control instruments into a radio transmission



Different types of IoT Devices

Software

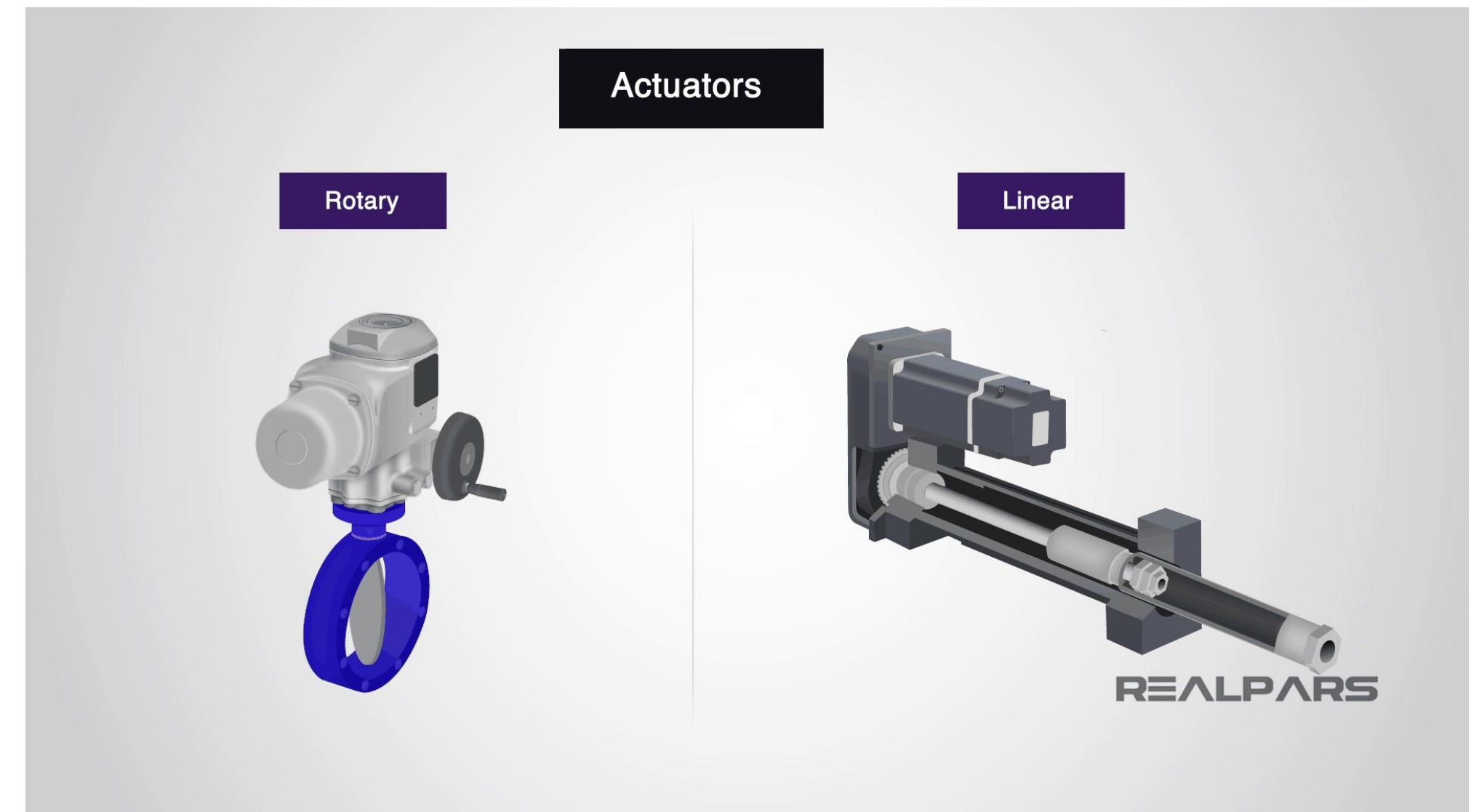
- It is a set of instructions and its documentations that tells a device what to do or how to perform a task.
- Software includes all different software programs on a device, such as applications and the operating system.



Different types of IoT Devices

Actuators

- It is a component of a machine that is responsible for moving and controlling a mechanism or system.
- It requires a control signal and a source of energy.
- An actuator is the mechanism by which a control system acts upon an environment.



Different types of IoT Devices

Computer Devices

- It is a unit of physical hardware or equipment that provides one or more computing functions within a computer system.
- It can provide input to the computer, accept output or both.
- A device can be any electronic element with some computing ability that supports the installation of firmware or third-party software.



Where can you find them?

IoT devices can be imbedded into:

- Mobile devices
- Industrial equipment
- Environmental sensors
- Medical devices

Where can you find them?

Mobile Devices

- A mobile device is a computer that is size is so small that can be hold and operate in the hand.
- They have a flat-screen interface and provides a touchscreen interface with digital buttons and keyboard or physical buttons along with a physical keyboard.
- They can connect to the Internet and interconnect with other devices.
- A mobile device consists of an integrated camera, the ability of placing and receiving voice and video calls, play video games and use the GPS.
- Power is typically provided by a lithium battery.



Where can you find them?

Industrial Equipment

- It covers any type of device that is used in the industrial world.
- It covers a very wide range of devices that include everything from ball bearings and air tools to large bulldozers, cranes, cement mixers and backhoes and just about everything in between such as compressors, check valves, couplings, dollies and dust collectors.



Where can you find them?

Environmental Sensor

- Environmental sensors are connected devices that are capable to provide various types of information, like includes location, position, the individual's movements and contextual elements.



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Where can you find them?

Medical Devices

- A medical device is any device intended to be used for medical purposes.
- The difference of this type devices from another everyday one is its intended use.
- Medical devices benefit patients by helping in their health care.



Why we should use IoT Devices?

What exactly is the use of an IoT device?

IoT devices are basically physical devices integrated with software and can connect with each other over the internet to exchange information, they help the user for more simple and direct integration of the physical world.

Why we should use IoT Devices?

- IoT devices are what makes IoT useful for business, whether they're transmitting environmental data from a manufacturing facility, information about a patient's medical device, insight into transportation logistics, or data from always-on smart home devices.
- With the help of an IoT device management platform companies can simply and securely provision, deploy, and update devices across the enterprise network. A platform also aids tracking and managing the ever-growing number of connected devices.

IoT Devices - Advantages

Advantages

- Ease of information access
- It encourages a machine-to-machine interaction
- Automation
- Cost Efficient

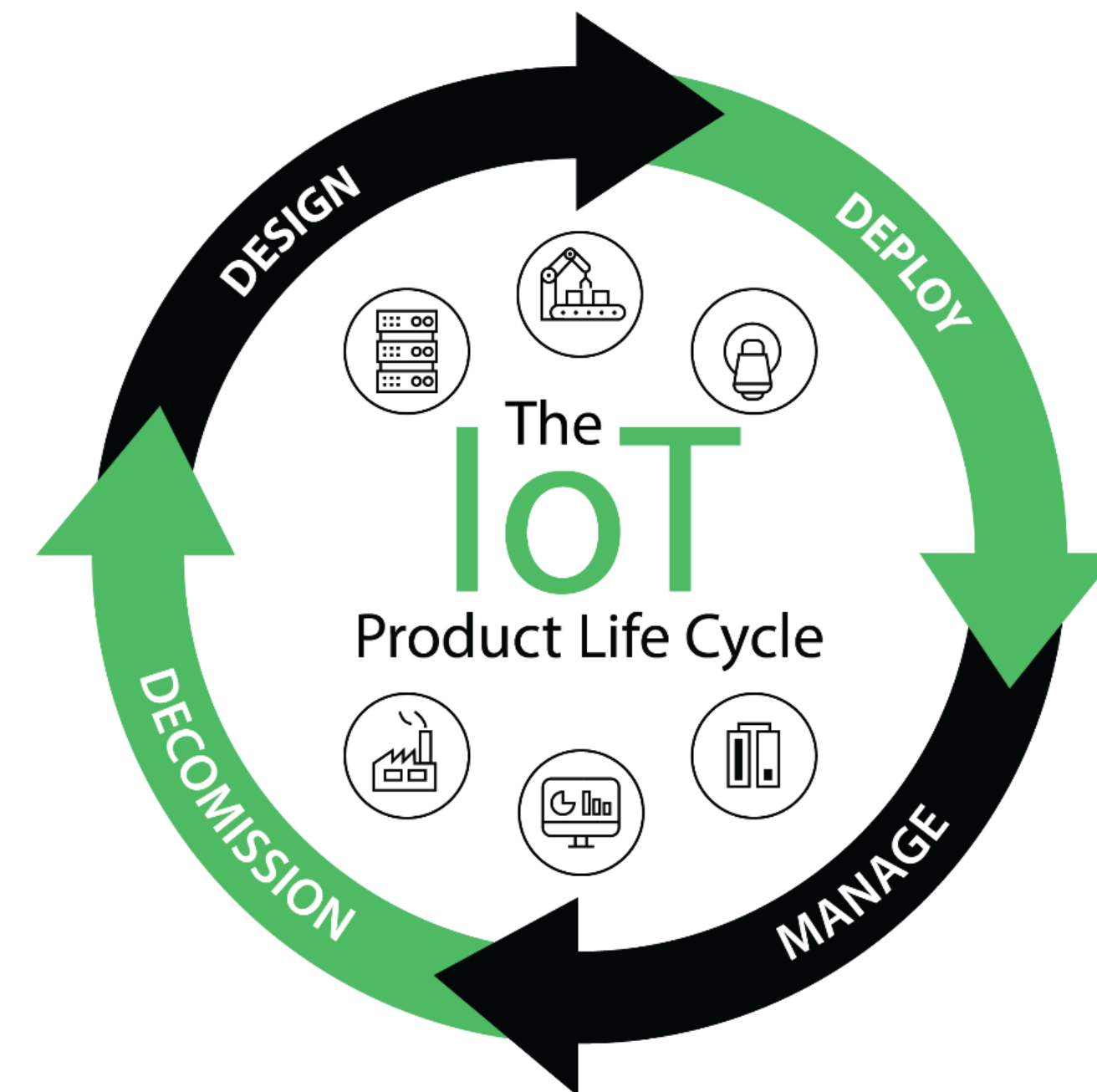
Disadvantages

- No international compatibility standard.
 - High complexity results in failure.
 - Affected by privacy and security breach.
 - Reduced safety for users.
- Job reduction.
- AI technology may take control of life.

IoT Device Lifecycle

IoT Device Lifecycle

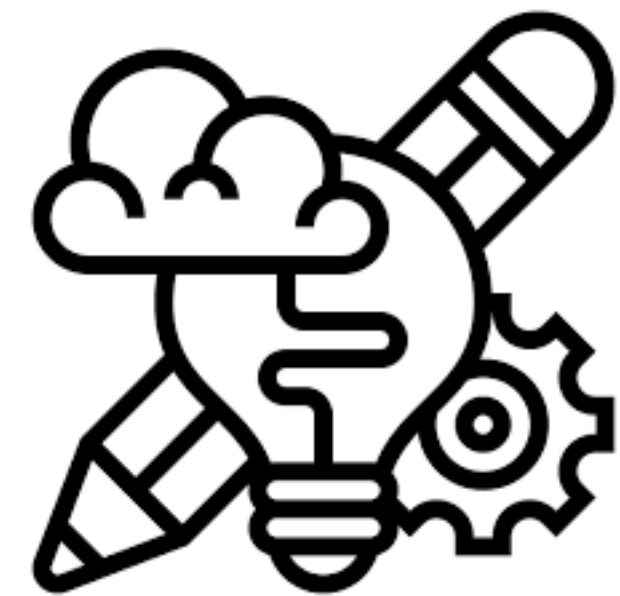
1. Design
2. Deploy
3. Manage
4. Decommission



IoT Device Lifecycle

Design

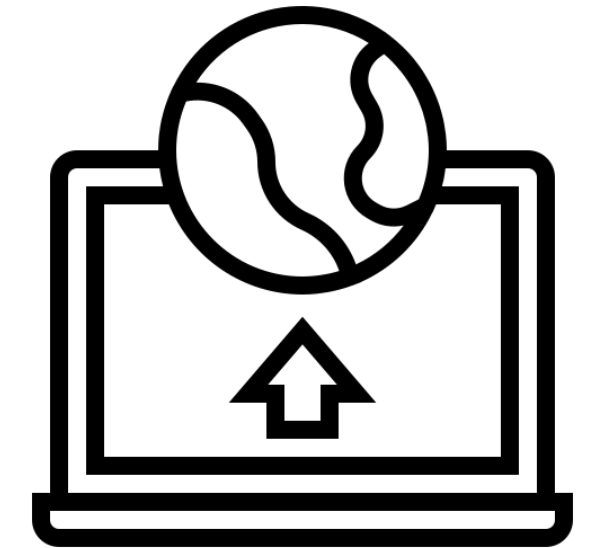
- the developers gather all information about an IoT device that include requirements and services.
- Decisions are made that include the hardware and software platform, communication type, sensor analytics, storage, alerts, network configuration, security, etc.
- Since IoT is susceptible to security breaches, an end-to-end security strategy must be considered



IoT Device Lifecycle

Deployment

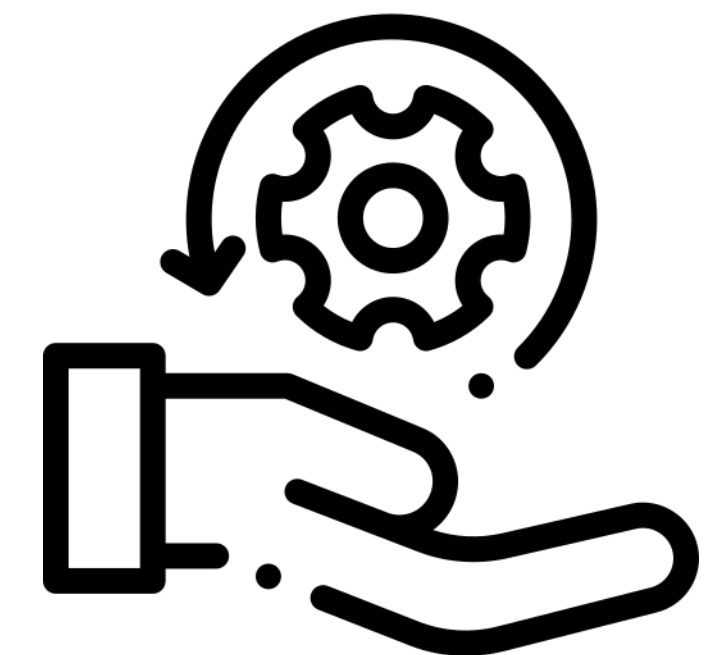
- It can be further divided into three phases: proof-of-concepts, pilots and commercial rollout.
- Preliminary presentation and configuration of an IoT platform in the field has to be done swiftly and smoothly.
- Planning deployment and activation of consumer products can ensure its success even at a large scale.
- Once an application has been tested, it is ready to be deployed.
- The developers require a medium to deploy it easily to numerous devices in the field.



IoT Device Lifecycle

Maintenance

- The maintenance phase is the longest phase of the lifecycle of an IoT device.
 - It starts from the beginning of the deployment phase and continues until the decommission phase.
- In the process of producing an IoT device, many stakeholders are involved and access the device for various reasons:
 - Providing maintenance
 - Providing updates
 - Optimizing its performance



IoT Device Lifecycle

Decommission

- It enables end users and stakeholders to remove a device from the system securely and deploy a new one.
- It does not expose a vulnerability due to which the system gets exposed to security breaches after removal of an IoT device from the system.



Why is the IoT Device Lifecycle needed?

- 1.To know the device
- 2.To improve productivity
- 3.Reduce downtime
- 4.Stay updated
- 5.Focus on customer satisfaction
- 6.Fix little things before big ones appear
- 7.Data feedback

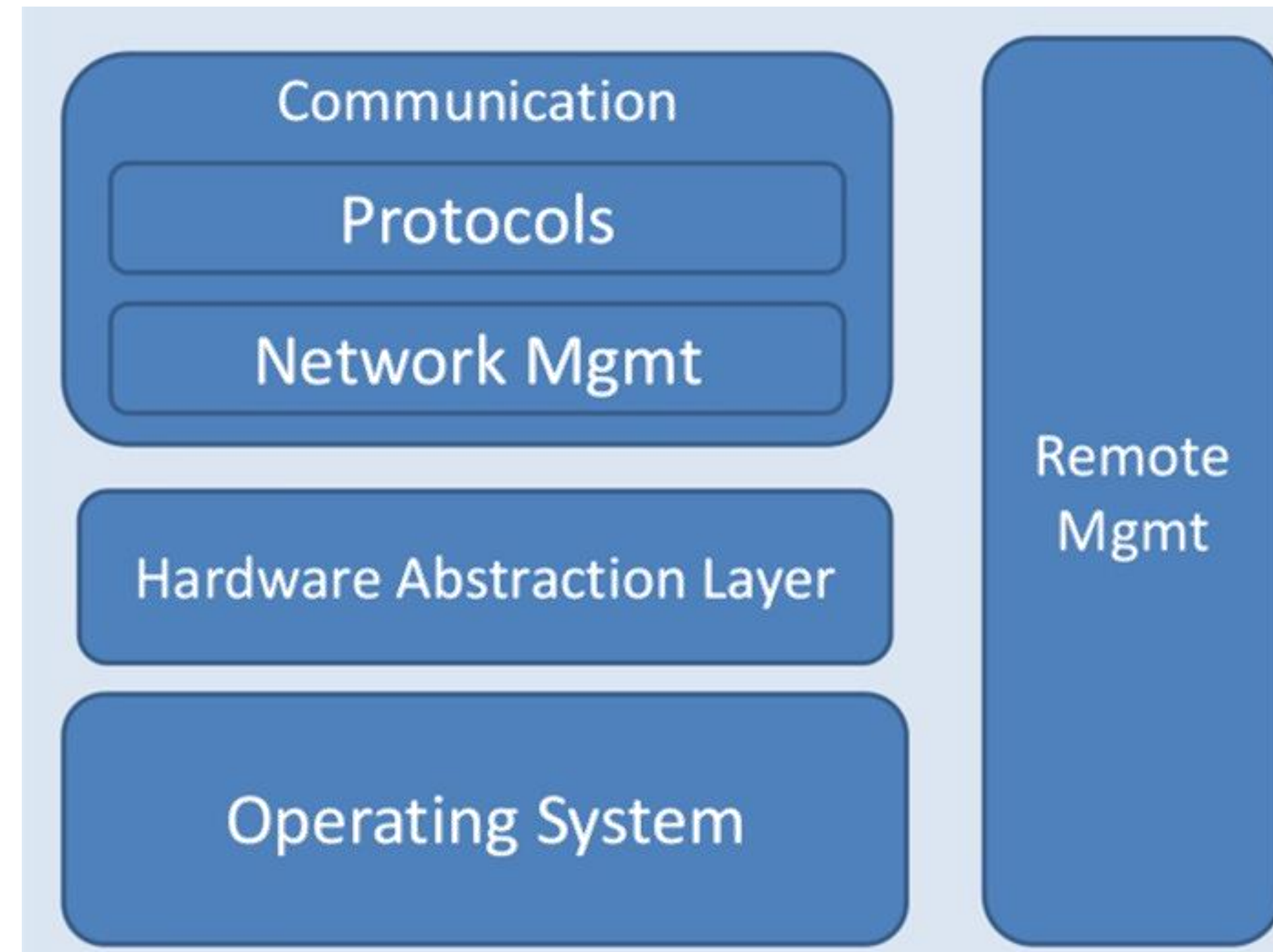
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Architecture and Management



IoT Device Architecture



Operating System

- Many IoT devices run bare metal firmware
- RTOS like mBed and freeRTOS

Hardware Abstraction

- Provides access to hardware features
- MCU, Flash, GPIO, Serial Interfaces and etc.

Communication Support

Wired/wireless protocols like:

- Bluetooth
- Z-Wave
- Zigbee
- Thread
- ...

Remote Management

- Monitor the device
- Upgrade firmware

Device Management

To ensure that the IoT device's functionality works as intended throughout its lifetime, certain management procedures need to be applied.

- It is not enough to just install it and let things go their way.

These connected devices require to adapt management procedures in order to maintain their performance:

- facilitate the interaction between them
- ensure secure data transmission
- and more...

Device Management Procedures

1. Device Identification
2. Configuration and control
3. Monitoring and diagnostics
4. Software updates and maintenance

Device Management Procedures

Device Identification

- It is responsible to establish the identity of the device.
- This is done in order to ensure that the device is genuine with trusted software transmitting reliable data.

Device Management Procedures

Configuration and control

- It is responsible to tune devices according to the purposes of an IoT system.
- When a device is installed, some parameters are needed to be written or updates might be needed.

Device Management Procedures

Monitoring and diagnostics

- It ensures smooth and secure performance of every device in the network.

- It reduces the risk of breakdowns.

Device Management Procedures

Software updates and maintenance

Software updates and maintenance
is responsible to:

- add functionality
- fix bugs
- address security vulnerabilities

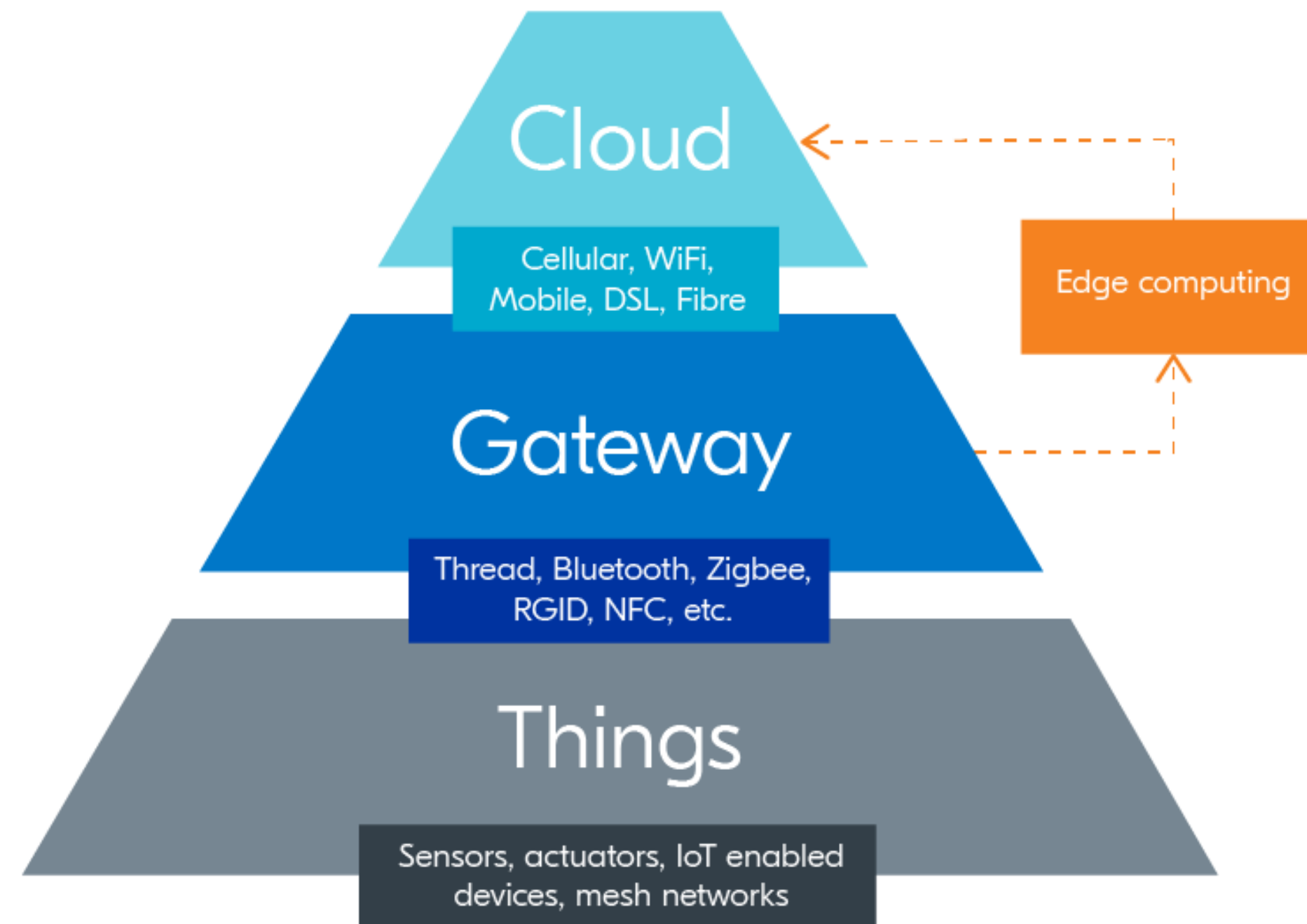
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Communication Architecture



Communication Architecture of IoT Devices



Cloud

- An IoT solution requires a data process that mostly takes place in cloud-based applications.
- A cloud-based application may have the following features:
 - Receive extensive quantities of data from devices via gateway solutions
 - Process and store the data
 - Enable communication with devices
 - Control registration of devices able to connect to the application
 - Provide monitoring and analytics
- These applications need an additional layer, called presentation or business intelligence, in order to allow non-technical users to interact with the IoT solution. This is done through dashboards or even reports than the application itself.

Edge Computing

- Sometimes it is possible for the cloud to either be unavailable or a quicker response time is needed, as a result a data off-device is required.
- To help in these cases, edge computing is used. Edge is the place where the data is produced and initially aggregated, such as static gateways, sensors, computers, smartphones, etc.
- The main idea is to work like a triage system, in order to collect and process data and only the material really needed is sent to the Cloud.

Gateway

- The gateway is the intermediate element that is required to be between the sensors and devices out in the field and the applications situated in the cloud.
- In cases where LTE/NB-IoT is used inside of the device, the devices are able to connect directly to the Internet without the help of a gateway.
- A gateway is connected to the Internet with the use of Wi-Fi or a wired Ethernet connection.

Things

- The things include sensors and devices.
- Home IoT Solution:
 - Smart devices connect to the Internet and enable communication with cloud-based apps, smartphone apps or other IoT devices.
 - Sensors collect data for the user as well as control actuators.
- Manufactures:
 - These devices can automatically report errors and aggregate as well as analyze data.
- Industrial and commercial:
 - The sensors are responsible to collect specific data or measurements in order to be processed and monitored by applications.

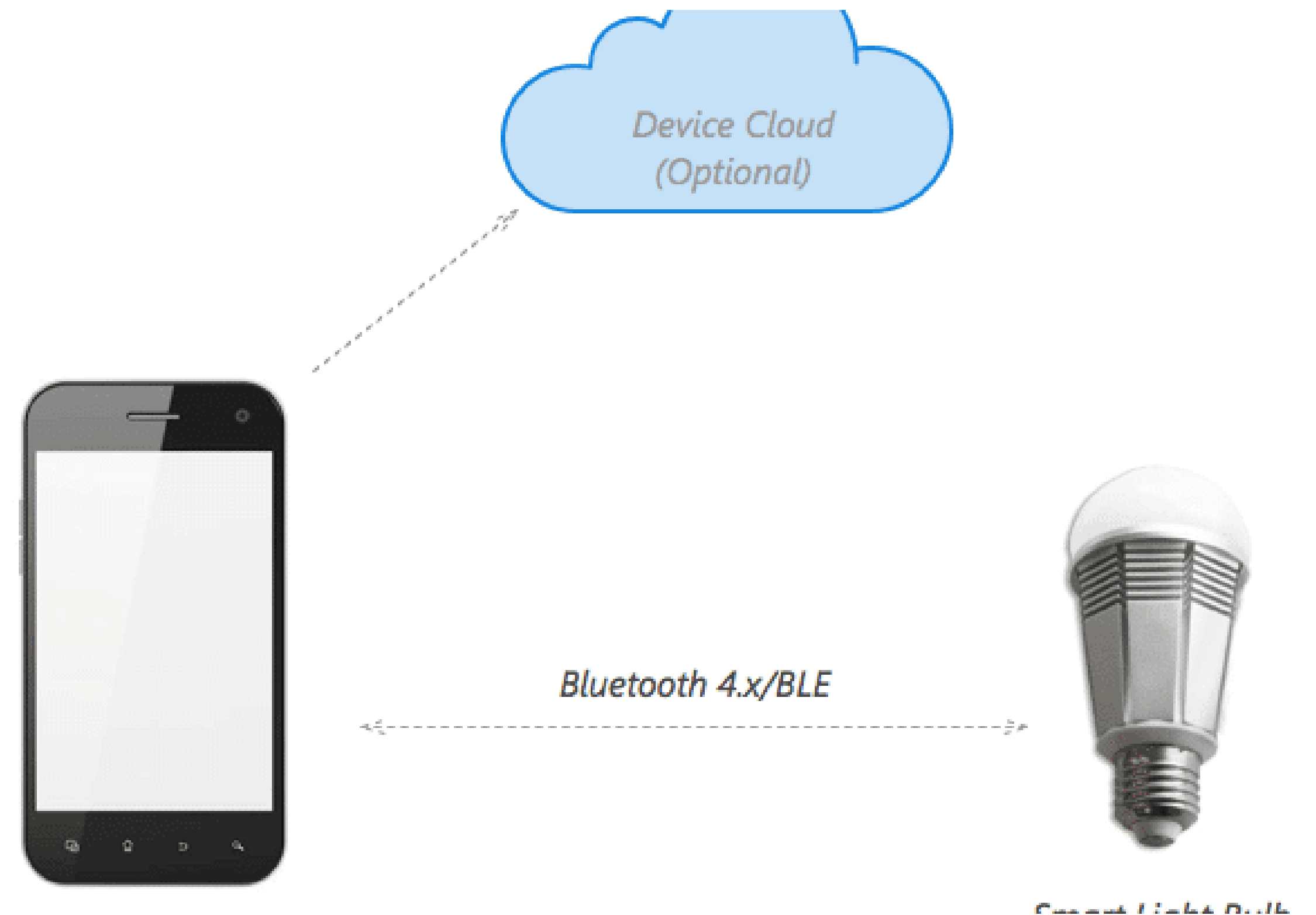
Software Communication Architecture

The software communication architecture of IoT devices can be divided into three types:

- Smartphone Centric Architecture (With Or Without Cloud)
- Hub-Centric Architecture (With Or Without Cloud)
- Cloud Centric Architecture (Without Hub)

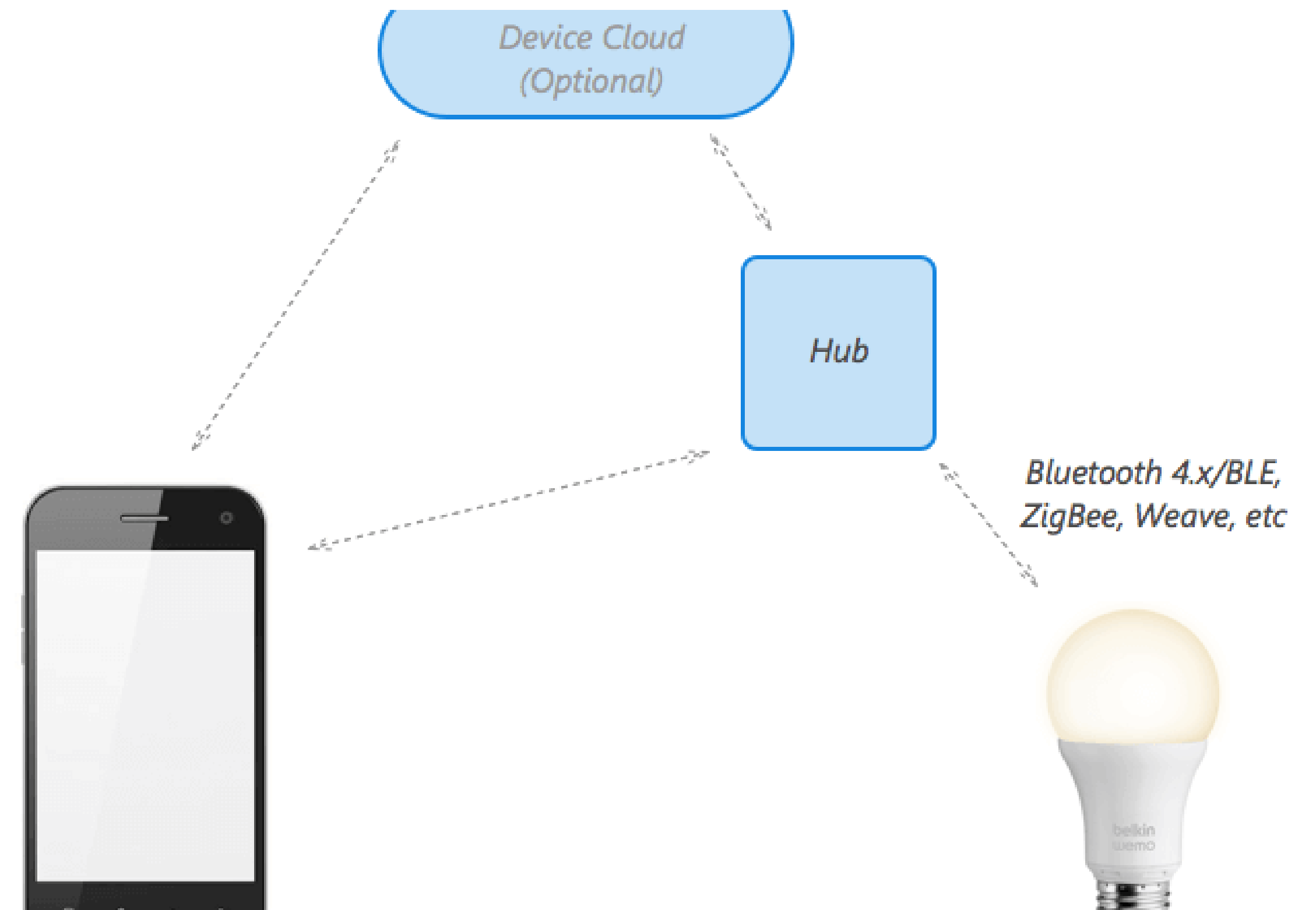
Smartphone Centric Architecture (With Or Without Cloud)

- The connection to the IoT device is only possible through the smartphone.
- Advantage:
 - Only one device is need to connect the IoT device to the Internet.
- Disadvantage:
 - Without the smartphone the IoT device is not able to connect to the Internet.



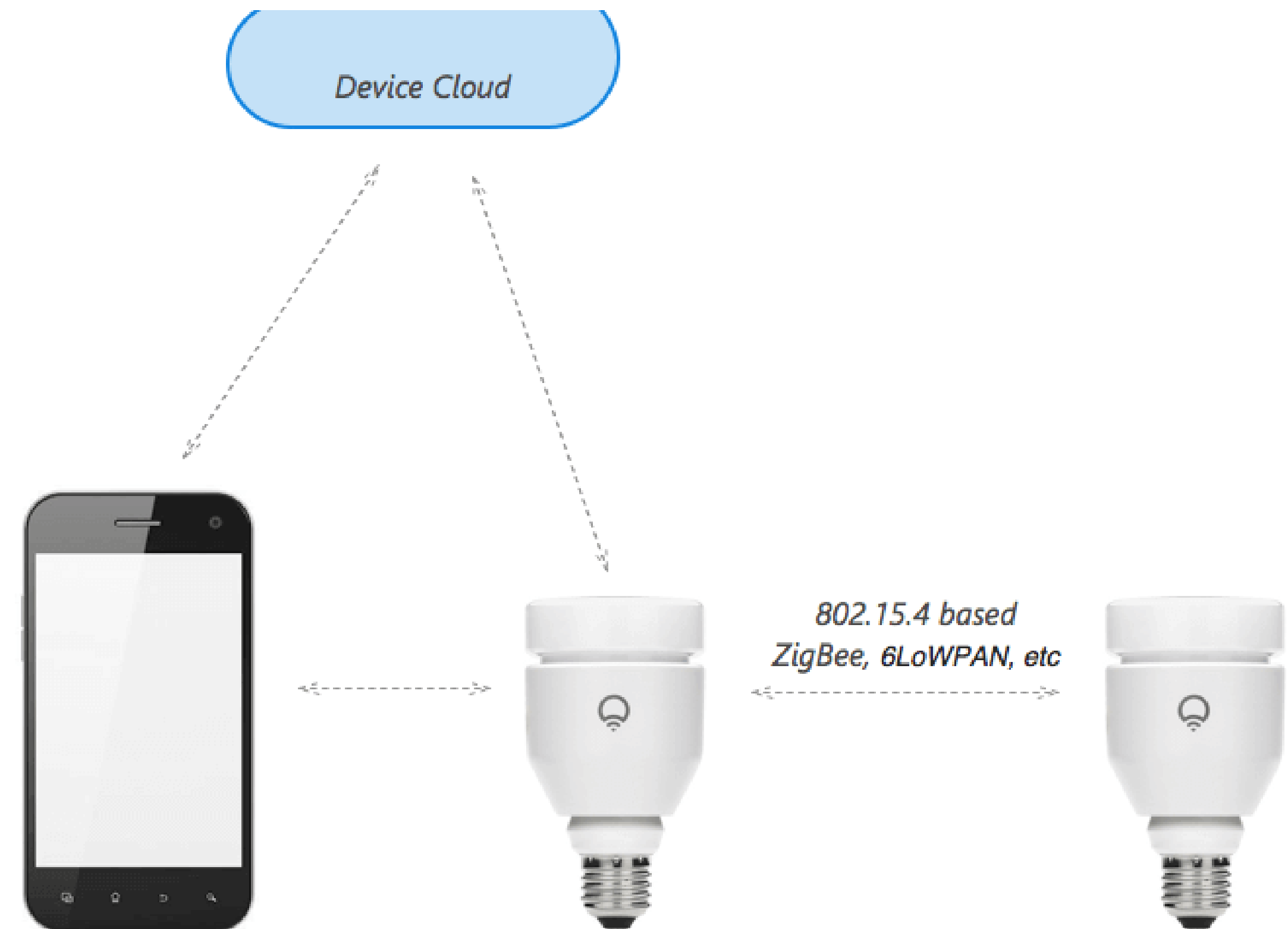
Hub-Centric Architecture (With Or Without Cloud)

- It uses a hub as an intermediary for the connection between IoT device to the smartphone and to the Internet.
- Advantage:
 - Independent of smartphone and always connected to the Internet.
- Disadvantage:
 - Procedure of installing new device to the connected network.



Cloud Centric Architecture (Without Hub)

- It directly connects the IoT device to the home WiFi network.
- Advantage:
 - No need to buy and install additional devices, like a hub.



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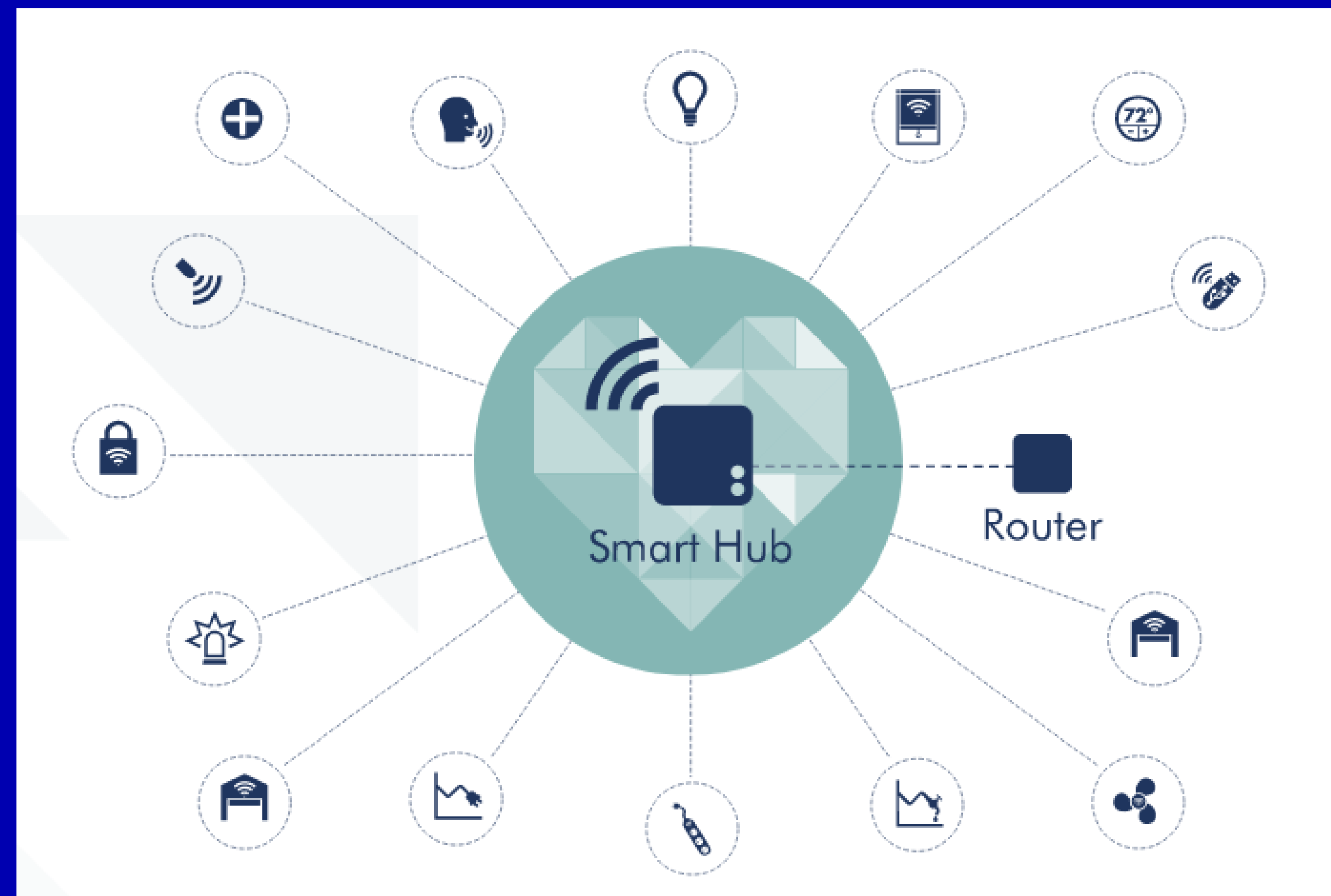
Examples

Examples of IoT devices

Different IoT devices can be found in different areas and be divided into the following categories:

- Smart Hubs and Controllers
- Smart Surveillance Cameras
- Smart Lighting
- Smart Heating and Cooling
- Smart Kitchen Appliances
- Smart Vacuums
- Smart Health and Fitness Devices
- Smart Watches
- Smart Outdoor Gadgets

Smart Hubs and Controllers



Google Home Voice Controller

It is a smart IoT device allowing users to enjoy features like media, alarms, lights, thermostats, volume control and other voice controls.



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Belkin WeMo Smart Light Switch

- It helps the user to manage its home lights from the wall, mobile phone or its voice.
- It is connected to the home WiFi network and gives wireless access to the lights.



Amazon Echo Family

- The Amazon Echo Family consists of:
 - Amazon Echo: is a smart Bluetooth speaker.
 - Amazon Echo Dot: is an Alexa-powered Bluetooth speaker.
 - Amazon Echo Show: is the Amazon Alexa-powered Echo Show smart display.
- Alexa is the Amazon's handy voice assistant.



Brilliant Control

- The Brilliant Control is a unique wall switch that uses Wi-Fi to connect to and control various smart devices in your home.
- It can let you play music, control lighting, set thermostat temperatures, and see who is at your door, etc.



Logitech Harmony Elite

The Logitech Harmony Elite is an ultimate universal remote control that is able to connect to any Bluetooth, Wi-Fi, Zigbee, Z-Wave, or infrared devices in your house through the Harmony Home Hub.



Ecobee Switch+

- The Ecobee Switch+ is more than just a smart wall switch that connects to your Wi-Fi and can be controlled using a mobile app.
- It can tell you the current news, weather and sports scores, play music, and control other smart home devices.



Samsung SmartThings Wifi Smart Plug

- The Samsung SmartThings Wifi Smart Plug is a smart plug that features power usage reports, voice control and flexible scheduling.
- It supports IFTTT applets, and it will integrate with other smart devices if you pair it with a SmartThings hub.



Smart Surveillance Cameras



Arlo Ultra

- Arlo Ultra is an outdoor camera that streams and records video in true 4K, or Ultra High Definition (UHD).
- It includes automatic zooming, motion tracking, color night vision, an integrated spotlight and siren, one-click 911 connectivity, a 180-degree field of view, etc.

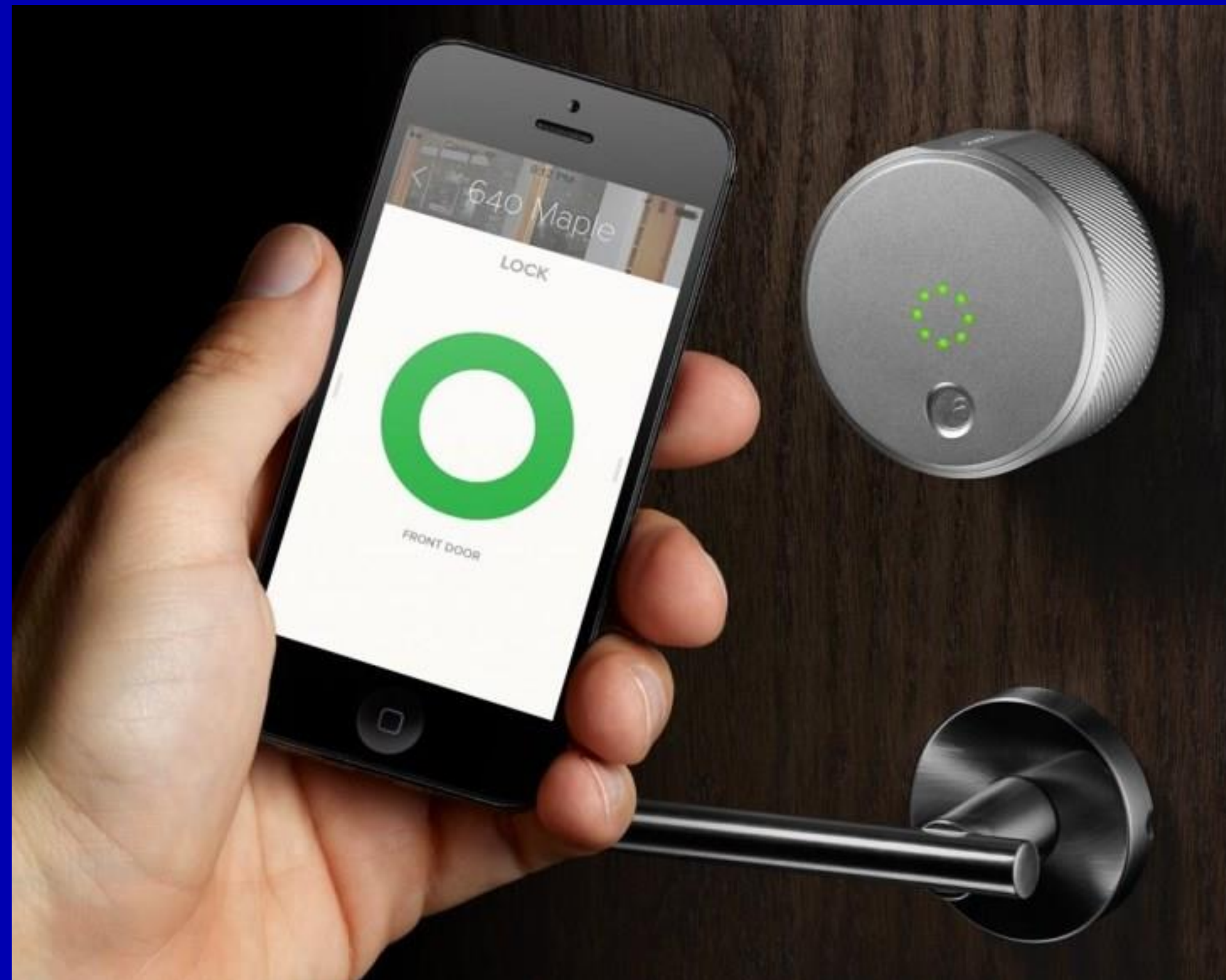


Wyze Cam Pan

- Wyze Cam Pan is a tiny, but capable 1080p home security camera.
- It includes motion and sound detection, time-lapse recording, and free cloud storage.



Smart Locks and Home Security Systems



August Smart Lock

- It is a proven reliable security IoT device.
- It allows the user to manage their doors from any location hassle-free.
- It helps users to keep thieves away from there home.



Ring Video Doorbell Pro

- The Ring Video Doorbell Pro is a smart doorbell.
- It lets you see who is at your door in real time, who came calling while you were away, and uses pre-buffering so you won't miss a thing.



SimpliSafe Home Security System

- The SimpliSafe Home Security System is about smart home security.
- It is perfect for keeping your home safe from intruders and environmental threats like fires and floods.



Smart Lighting



Philips Hue Family

- The Philips Hue line delivers with bulbs that let you control not only the intensity of the light, but also the color.



Yeelight Smart LED Bulb

- The Yeelight Smart LED Bulb offers 16 million colors, and connects to your home network wirelessly, without the need for a hub or bridge.
- It supports Apple HomeKit, IFTTT, and Alexa, Google, and Siri voice commands.



Wyze Bulb

- The Wyze Bulb is a white LED light that can be controlled by voice, phone, and lots of other smart home devices.



Philips Hue White and Color Ambiance Lily Outdoor Spot Light Kit

- The Philips Hue White and Color Ambiance Lily Outdoor Spot Light Kit makes it easy to bring mood lighting to your yard and garden.



Smart Heating and Cooling



Ecobee Smart Thermostat With Voice Control

- The Ecobee Smart Thermostat With Voice Control is a smart thermostat.
- Its features include Alexa support, a touch display, a remote room sensor, and interoperability with lots of other smart home devices.



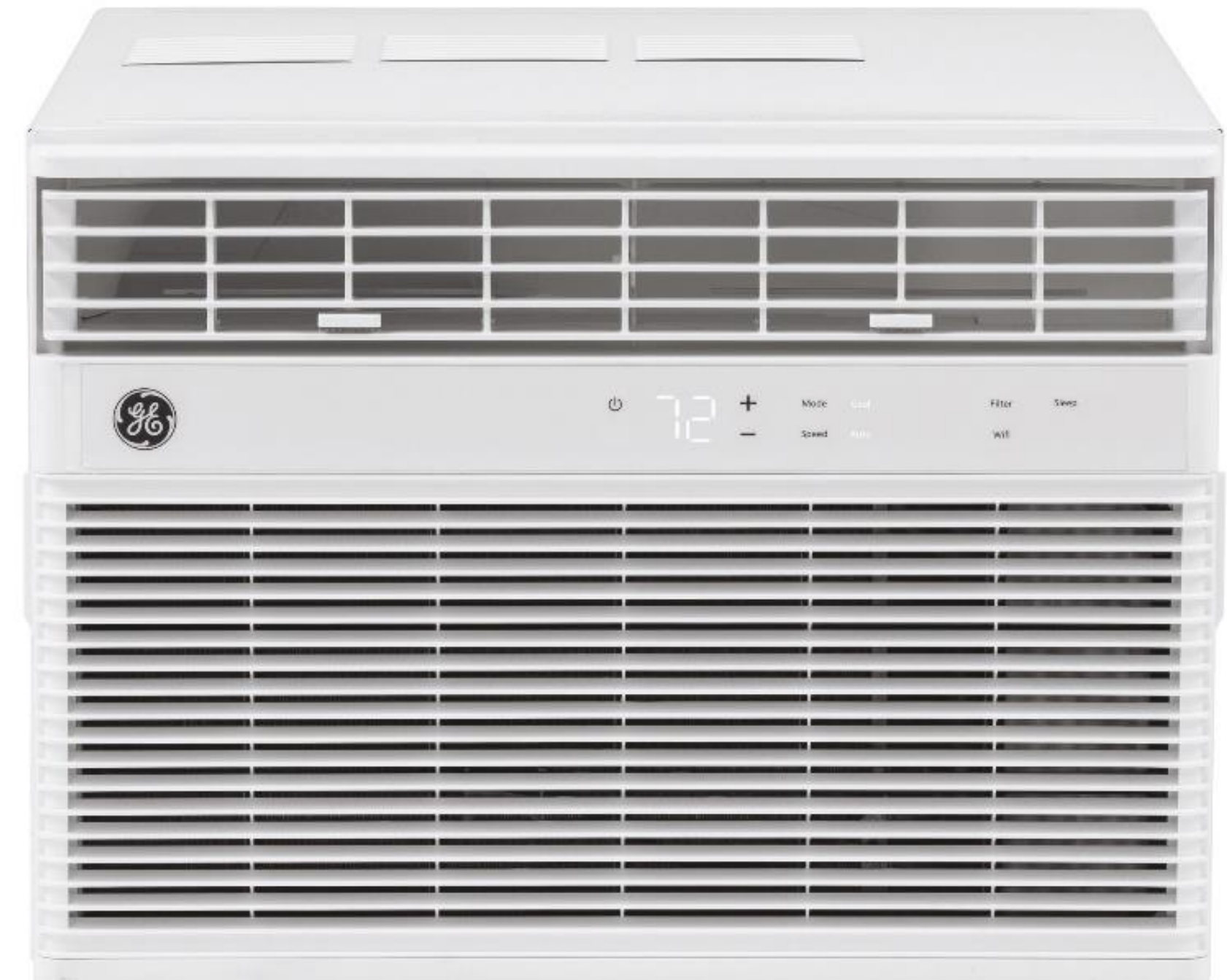
Nest Learning Thermostat

- The Nest Learning Thermostat is a smart thermostat that has Wi-Fi so you can remotely control the temperature from phone, tablet, or PC.



GE Energy Star 115-Volt Electronic Room Air Conditioner

- The GE Energy Star 115-Volt Electronic Room Air Conditioner AHC08LY is an 8,000-BTU Wi-Fi-enabled window unit that you can control with your phone or with your voice.
- It also uses your phone's location services to cool down rooms in your home before you arrive and offers flexible scheduling options and energy usage reports.



Smart Kitchen Appliances



Traeger Ironwood 650

- The Traeger Ironwood 650 is a wood pellet grill that is equipped with Wi-Fi and variable speed convection fans, which makes barbecue, roast, and smoke easy.



August Smart Lock

- The AmazonBasics Microwave is a small, simple microwave oven that is able to respond to Alexa voice commands.



Samsung Family Hub 4-Door French Door Smart Refrigerator

- This smart refrigerator not only stores food but is able to set expiration notifications for the food stored, plan meals based on the available ingredients in it and see the content inside it from anywhere.
- Photos can be shared and calendars on the screen can be synced, as well as be able to control smart home devices like lights, thermostats, and doorbells, and stream music, with voice commands.



Instant Pot Smart WiFi 8-in-1 Multicooker

- The Instant Pot multicooker is able to be access with WiFi or voice command and also supports Alexa.
- The user is able to plan dinner with the help of Alexa and the app gives the opportunity to control and adjust cook settings and check the progress of the meal.



2-Slice High Speed Smart Toaster

- The smart toaster is a touch-screen toaster that consists of smart cooking sensors in order to perfectly toast bread, bagels, waffles, toaster pastries, and English muffins.



Smart Vacuums



Ecovacs Deebot N79S

- The Ecovacs Deebot N79S robot vacuum is a powerful cleaning device with app control and Alexa voice command support.



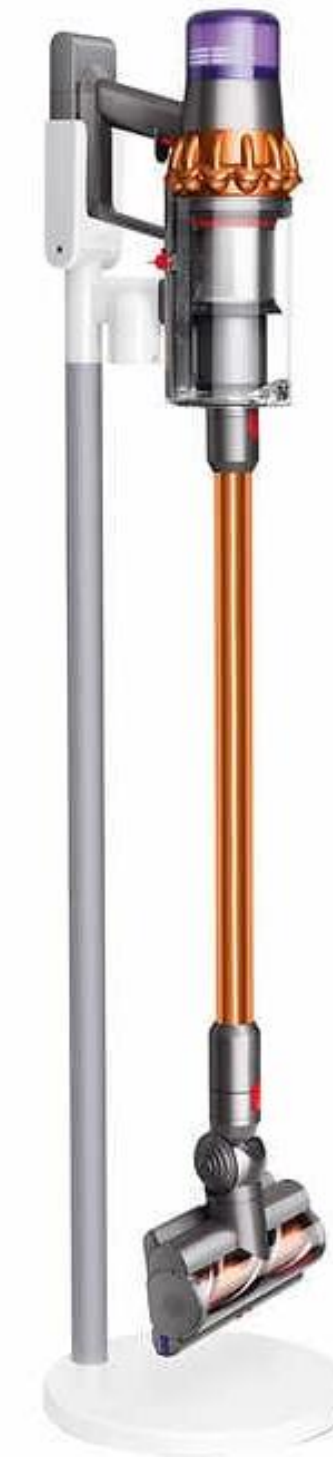
August Smart Lock

- iRobot's Roomba s9+ is a smart vacuum with intelligent navigation, super-powerful suction, and the ability to empty itself out.



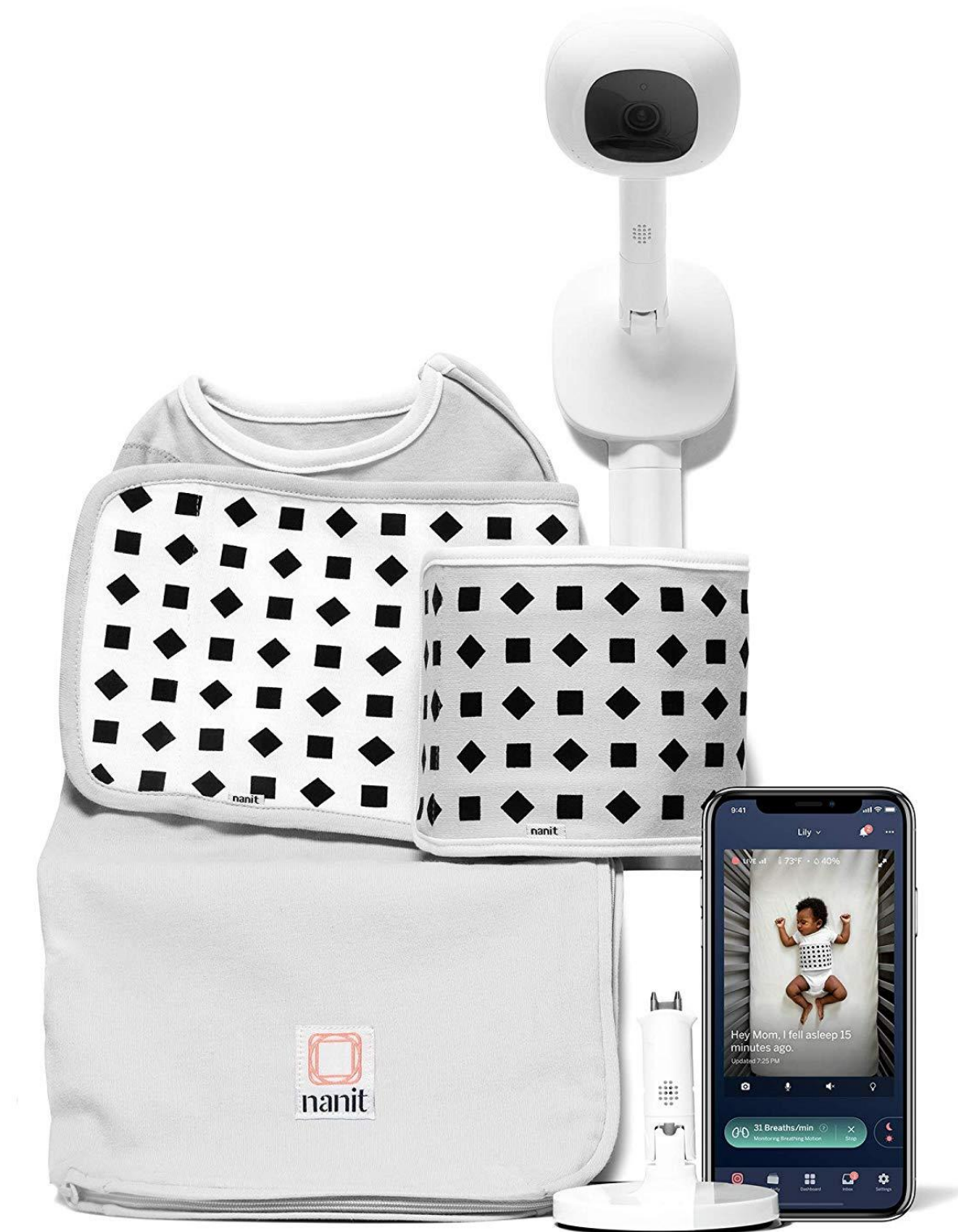
Dyson V11 Torque Drive

- Dyson's V11 Torque Drive is a smart cordless stick vacuum that can automatically detect the type of surface and switch the motor speed accordingly, in order to blend right the power and battery life.
- An LCD on top of the handle shows remaining battery life (down to the second), your current power mode, reminds you to clean the filter, and tells you how to clear any blockages.



Nanit Plus

The Nanit Plus is a smart baby monitor that is able to track the baby's sleep and monitor its breath.



QardioBase 2

The QardioBase 2 is a smart scale that is able to track fat, BMI, water, muscle mass, bone composition, and even pregnancy



Sleep Number 360 Smart Bed

- The Sleep number 360 smart bed includes a smart mattress that is able to track the user's sleep with the use of biometric sensors.
- With the use of a smartphone app the user is able to view its sleep trends and health metrics.



Oura Ring

- Oura Ring is a smart ring that is able to track your sleep and activity.
- It includes pulse measurements, 3D accelerometer, gyroscope and body temperature sensor.



August Smart Lock

- The Muse Brain-Sensing Headband is a smart headband ideal for meditation.
- It is able to guide the user into a relaxed state of mind.
- The smartphone app is able to be used for data reviews and setting future goals.



Smart Watches



Apple Watch

- The Apple watch is a smart watch that comes with an always-on display and is a perfect match for user that have Apple's phones.



August Smart Lock

- The Samsung Galaxy watch active 2 is a smart watch with a touch-screen.

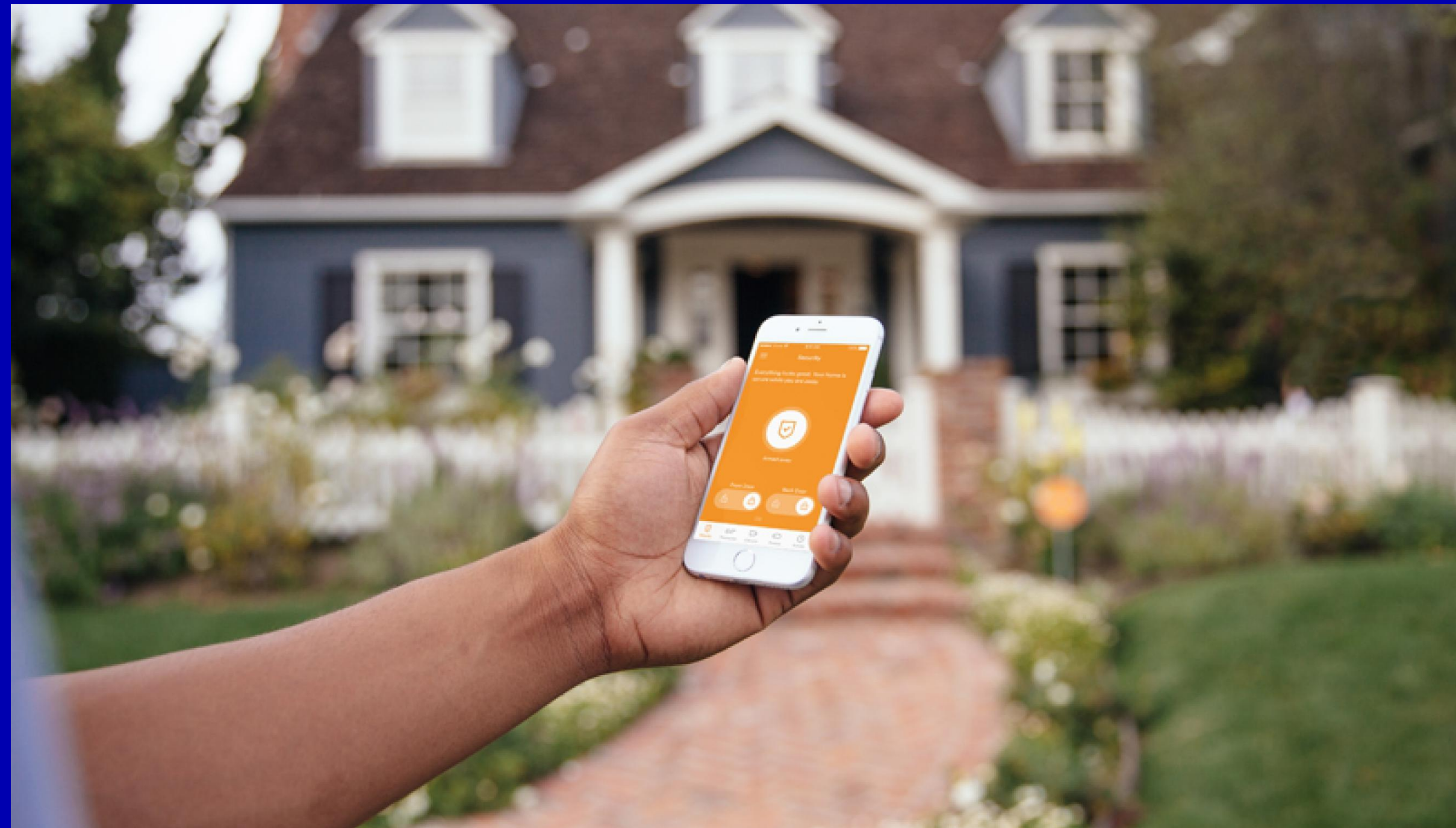


Fitbit Ionic

- The Fitbit Ionic is a smart watch that is able to track the user's fitness level.



Smart Outdoor Gadgets



Polaris 9650iQ

- The Polaris 9550 Sport is a robotic pool cleaner.
- It has a Wi-Fi connectivity and a mobile app that lets the user to control the cleaner.
- It contains superb cleaning performance, easy-to-clean debris canister, and multiple programming options.



Husqvarna Automower 315X

- Husqvarna Automower 315X is a robot lawn mowers for yards of all shapes and sizes.
- It works with the use of a mobile app that is able to start and stop the mower, monitor the process of it, create schedules and find its location on the map.



Summary

- Introduction to IoT Devices
- IoT Device Lifecycle
- Architecture and Management
- Communication Architecture
- Examples